Surface Mooring Survivability in The Littoral Regime

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LONG TERM GOALS

We seek to develop an engineering tool to aid in the design of shallow-water surface moorings that can withstand low-cycle, high-stress fatigue that occurs in littoral environments and high cycle fatigue that occurs in deeper waters of the Continental Shelf.

OBJECTIVES

Our research on the cyclic fatigue of mooring components has shown that it is possible to quantify the effect of this failure mechanism on the life of mooring components. However, there does not exist at this time a specific design procedure or manual that can be passed on to oceanographic engineers for future moorings, especially those having different performance requirements and hardware. The objective of this project is to develop and document a set of design procedures for shallow-water moorings that quantifies probabilities of failure from extreme loads (ultimate failures) and cyclic loads (fatigue failures). The design procedures will emphasize state-of-the-art-modeling techniques that are more cost effective than cyclic testing and more accessible to oceanographic engineers.

APPROACH

Our approach combines cyclic testing of mooring components with structural analysis using finite element methods, cable dynamics using finite difference schemes and full-scale experiments at the Woods Hole Oceanographic Institution (WHOI) Buoy Farm. A full-scale test mooring has been designed with components that are predicted to experience high fatigue life-loss during the deployment.

WORK COMPLETED

The first phase of laboratory hardware testing has been completed by the Massachusetts Materials Research, Inc., of West Boylston, MA. Two sizes of shackles from two manufacturers were tested in a total of seven tests. Each test consisted of a sample of eleven shackles. The first three tests were used to determine the ultimate breaking strength of 1/2" and 3/4" shackles manufactured by Columbus McKinnon and 3/4" shackles manufactured by Crosby Group. We conducted cyclic fatigue tests on new 1/2" and 3/4" shackles. This was followed by cyclic testing of used 3/4" shackles that had been recovered from the central discus mooring of the Coastal Mixing and Optics Experiment which had been deployed on the Continental Shelf for 11 months from July 1996 to May 1997.

In addition to the laboratory testing of hardware, a field test at the WHOI Buoy Farm is currently underway. A surface mooring with a three-meter discus buoy was deployed on October 8, 1999. The surface buoy is instrumented with a motion package and mooring tension recorder. Tension data is telemetered via satellite through Service Argos. The mooring contains a string of twenty 1/2" shackles approximately three meters below the buoy bridle. To simulate a typical subsurface instrument load, three 1200-pound depressor weights are in line on the mooring below the test shackles. The test shackles are intentionally smaller than the conventional 3/4" shackles normally used on such a mooring so that they will lose a significant percentage of their fatigue life over the course of the winter deployment. A safety chain parallels the test specimens. If one of the test shackles fails the telemetered tension signal will drop to zero and the safety chain will take up the load. The drop in tension will indicate a component has failed at which time we will arrange for the recovery of the mooring.

RESULTS

Comparison of the used hardware from the Coastal Mixing and Optics Experiment and new hardware showed that there was no significant degradation in the fatigue strength of the used components over the life of the deployment. In fact, there may have been a slight increase in fatigue strength due to work hardening.

IMPACT/APPLICATIONS

At the end of the research we will have a comprehensive design procedure for analyzing the fatigue characteristics of shallow-water oceanographic moorings. The design procedure will be the link between *WHOI Cable* software for predicting tensions in moored instrument strings and final designs of moorings that oceanographers can confidently deploy for long periods of time.

TRANSITIONS

The design procedure will be documented in a WHOI blue-cover report which will serve as a design manual that engineers can use to predict survivability of oceanographic surface moorings.

RELATED PROJECTS

The dynamic analysis of the surface mooring and the predictions of long-term statistics of the dynamic tensions acting on the test components was performed with numerical codes and analytical models developed as part of the project *Understanding the Dynamics of Shallow-Water Oceanographic Moorings* (ONR Award # N00014-92-J-1269 Ocean Engineering and Marine Systems Program Code 321OE).